Smith Myers
Communications Ltd.

1 SID Country Codes

In order to allow the testing of cellular telephones intended for use in countries other than the USA, the ART-875 now has the ability to allow the user to set the country specific part of the System Identification (SID). The SID is transmitted by the ART-875 and should be set to correspond to that expected by the cellular telephone.

The currently selected country code is battery backed up and is displayed as part of the ART-875 power up sequence - between the copyright display and the main menu display (see sections 3.1, 3.2).

There is now an additional item on the Setup menu - `Set country` which may be used to select one of the four different country codes.

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SMITH MYERS COMMUNICATIONS LTD.
ADVANCED RADIO TESTER 875 (ART-875)
USER MANUAL

RELEASE 003

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1 INTRODUCTION

The ART-875 is a sophisticated piece of portable test equipment for cellular telephones. It allows detailed testing and adjustment of all cellular telephones which comply with the AMPS specification. Test facilities provided by the ART-875 include call processing and measurement of carrier frequency, RF power, audio frequencies, and audio modulation.

The ART-875 is available in two versions, one suitable for a 120 V AC supply, the other suitable for a 240 V AC supply.

The ART-875 accessories supplied as standard are:

- internal rechargeable batteries
- an internal battery charger
- an AC mains cable
- a 1 metre BNC to BNC coaxial RF cable
- a SINAD cable
- two 20 dB attenuators.

A list of optional accessories may be obtained from your supplier.

1.1 CAUTIONS

The ART-875 is a sensitive electronic measuring instrument and should be treated as such. It has been designed for both indoor and outdoor use but note that it is not waterproof. Contact with water, dust, smoke and prolonged contact with direct sunlight should be avoided. Particular care should be taken to prevent liquids from entering the unit via the ventilation holes beneath the front panel and the switches and connectors on the back panel.

The ART-875 should not be stored or operated at temperatures outside those given in Section 9.

To prolong the life of the internal batteries, the practices laid out in Section 2.6 should be adhered to.

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Under no circumstances should the case of the ART-875 be opened by anyone other than a qualified service engineer. As well as high voltages, the internal components of the ART-875 contain substances which may be harmful if exposed. Namely:

- beryllium oxide,
- lead acid batteries.

1.2 CALIBRATION

To ensure the integrity of measurements made, the ART-875 should be returned for calibration at least once per year.

Details of your nearest authorised calibration centre may be obtained from your supplier.

2 PHYSICAL DESCRIPTION

2.1 KEYPAD

The ART-875 keypad is located on the front panel and is used to set up and perform tests to be made. It comprises four keys: ▲ ▼ ◆ and ✱ (see Figure 1).

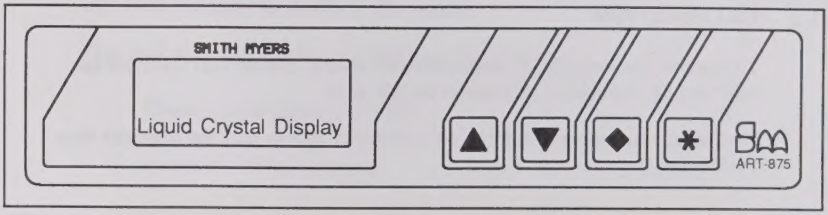

Figure 1 – Front Panel

When the ART-875 is switched on it will confirm each key depression with a short tone on the internal loud speaker.

The ▲ and ▼ keys are repeating keys. This means that if the key is depressed for more than 0.8 seconds it will repeat rapidly. This is useful when moving around in a large menu (section 3.2).

2.2 DISPLAY

The liquid crystal display (LCD) is located on the front panel (see Figure 1) and is used to instruct and inform the user. To allow the LCD to be read under poor lighting conditions, it may be illuminated by an internal back-light which may be turned on or off using the ✱ key (Figure 1) when the ART-875 is switched on.

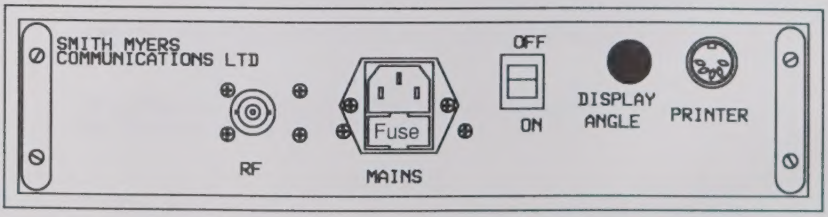

Figure 2 – Back Panel

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The contrast of the LCD will vary with the angle at which it is viewed and may be adjusted with the control labelled 'DISPLAY ANGLE' on the back panel (see Figure 2). This control will adjust the contrast of the display whether the ART-875 is switched on or off though its effects may only be seen when it is switched on.

2.3 PRINTER/SINAD SOCKET

This socket is located on the back panel and is labelled 'PRINTER' (see Figure 2). It may be used to connect the ART-875 to a printer when a permanent copy of the results of a test is required, or to the speaker output of a cellular telephone when performing a 'Sinad test' (Section 6.2).

The specifications for the cables which may be connected to this socket and for the printer are to be found in Section 8.

2.4 RF SOCKET

This socket is located on the back panel and is labelled 'RF' (see Figure 2). One end of the supplied RF cable should be connected to this socket, the other end will be connected to the cellular telephone being tested or to some auxiliary equipment.

NOTES: Only an RF cable of the type and length supplied is suitable for this connection.

The power of a signal applied to this socket should not be greater than 10 watts.

2.5 POWER SOURCE

The ART-875 may be powered from its internal batteries or from an external AC supply using the mains cable supplied. The ON/OFF switch and the mains socket are located on the back panel (see Figure 2).

The mains socket is protected with an integral fuse which may be renewed by the user if necessary (see Section 9 for rating).

The ART-875 should be switched off before removing or applying the AC supply.

2.6 INTERNAL RECHARGEABLE BATTERIES

The ART-875 contains rechargeable batteries which when fully charged, are capable of powering it for at least one hour away from the AC supply.

To quickly recharge the batteries, the ART-875 should be switched off and connected to the AC supply, in which case discharged batteries will be fully charged within 6-8 hours.

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The batteries will also be charged if the ART-875 is connected to the AC supply and simultaneously in use, in which case discharged batteries would be fully charged within 12-14 hours. Note however that completely discharged batteries should be recharged for 20 minutes with the ART-875 switched off, before it may be simultaneously charged and used.

The batteries can not be overcharged and will not be damaged if the ART-875 is left connected to the AC supply for extended periods. They can however be damaged if they are left completely discharged for periods greater than 14 days. For this reason, if the ART-875 is to remain unused for extended periods, the batteries should first be fully charged and subsequently recharged at six-monthly intervals.

Rechargeable batteries eventually 'wear out', i.e. they become unable to retain charge as well as they once did. The ART-875 batteries may be charged and discharged several hundred times before any noticeable degradation in performance. If a battery change is necessary, it should be performed only by an authorised service centre.

Certain user changeable quantities mentioned later on in this manual (see for example Section 3.3.2) are described as being 'battery backed up'. This means that their values are retained by the ART-875 whilst it is switched off and will not have to be set up each time it is switched on. Note however that if the internal batteries are allowed to discharge completely then these values will not be retained.

Bearing in mind the previous paragraph, the ART-875 should not be turned off by simply removing the AC supply and then left, as this may cause the batteries to become completely discharged.

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3 OPERATION

3.1 POWER UP SEQUENCE

When the ART-875 is switched on, it will perform a self-test and show a display similar to the following on the LCD.

```
ART-875 00/00  ◆CONT
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  Selftest: passed
 power is AC supply
```

An audio indication will also be given if the self-test has passed. On the fourth line of the display is given an indication of the type of power being used (`AC supply` or `battery`), which should be checked to ensure that it is as expected.

After a few seconds the display will change to that of the main menu (described in the next section), although this may done immediately if desired by pressing the ◆ key.

If there is no display at all then:

- the display contrast control may need to be adjusted (see Section 2.2),
- the batteries may need to be charged (see Section 2.6).

If the above have been tried and there is still no display, or if the ART-875 has displayed `power is battery` when `power is AC supply` was expected then:

- the mains socket fuse may need to be renewed (see Section 2.5),
- the mains cable plug fuse may need to be renewed.

If during the power up sequence or at any time after, the display reads;

```
BATTERY DEAD
```

then the internal battery charge is too low to continue and the batteries must be recharged (see Section 2.6).

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If the ART-875 has adequate power and the power up sequence is not as described above then a fault exists and the ART-875 must be repaired.

Details of your nearest authorised service centre may be obtained from your supplier.

3.2 MENUS

Tests are selected and parameters set up on the ART-875 by the use of menus. An ART-875 menu is a list of items displayed on the LCD from which the user must make a selection.

The first menu displayed after the power-up sequence is the 'main menu' which initially appears as shown:

```
     MAIN MENU
◆Automatic test
 Manual tests
 Set up                ▼
```

The top line contains the menu title or heading. The remaining three lines contain menu items.

An item is selected from a menu by positioning the ◆ symbol in the left most column of the display alongside the item to be selected and then pressing the ◆ key. The ◆ symbol may be moved from one item to another by pressing the ▲ or ▼ keys.

If (as with the main menu) a menu contains more than three items, only a part of the menu may be displayed at any one time. This will be indicated on the LCD by the ▲ and ▼ symbols. Each of these symbols indicates that there is more of the menu than can be currently seen in the direction pointed to by the symbol.

An attempt to move the ◆ symbol to an item on the menu which is not currently displayed will cause the display to scroll one line and display that item.

Some menus contain `Quit` as their last item, this should be selected if no item on the currently displayed menu is required, and the display will return to that of the previous menu. The complete menu structure of the ART-875 is shown pictorially in Figure 3.

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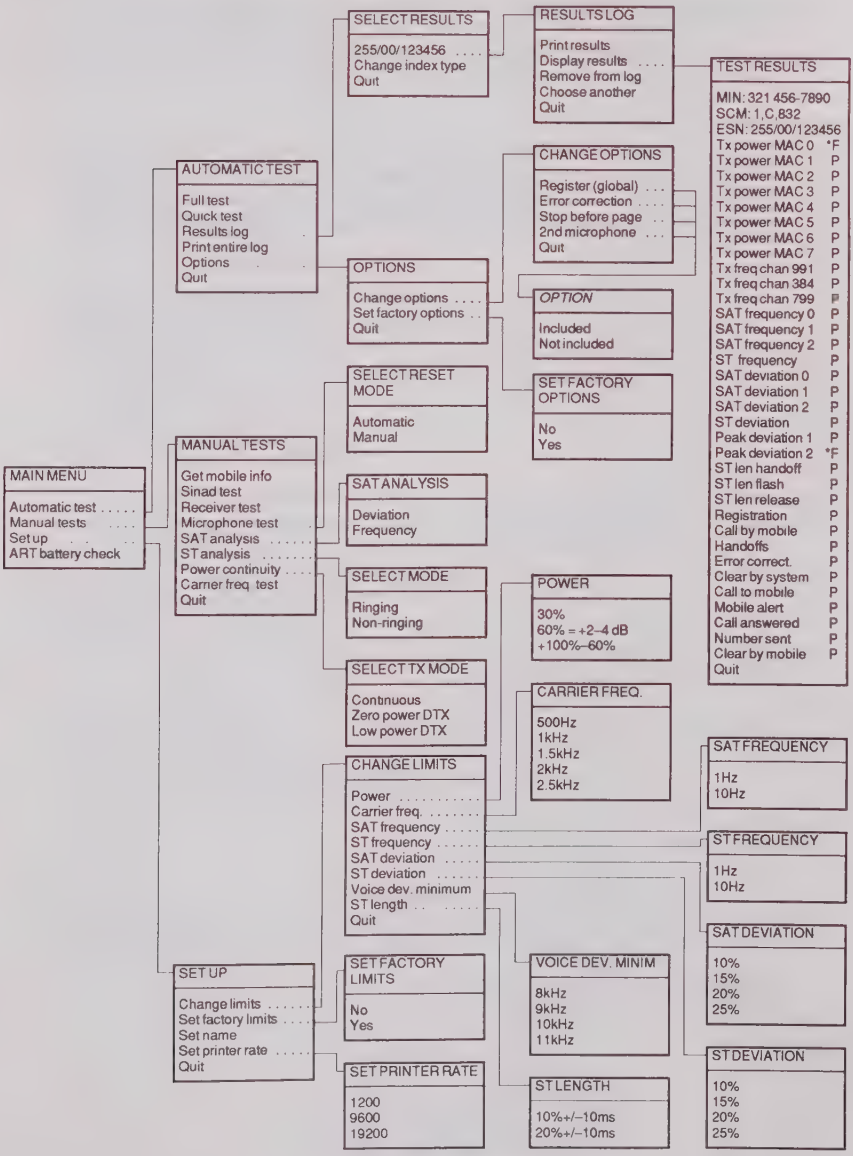

Figure 3 – Menu Structure

3.3 SET UP MENU

This menu is selected from the main menu (see Figure 3) and allows the the user to alter certain global parameters.

3.3.1 LIMITS

ART-875 limits are used by the Automatic test and some of the Manual tests to determine whether a measured value should pass or fail. The limits are battery backed up (see Section 2.6) and may be changed by the user if desired.

Any alterations to the limits made by the user may be effectively cleared by selecting `Set factory limits` which resets all limits to their factory settings. This selection must be confirmed and a further selection of `Yes` or `No` is required (see Figure 3).

The current value of a limit may be viewed or changed by selecting the `Change limits` menu and from there selecting the individual limit to be viewed or changed.

When an individual limit has been selected from the `Change limits` menu, the ART-875 will display a menu of the values which may be selected for that limit, in which the ◆ symbol will be initially displayed alongside the value which is currently selected. If no change is required, the current value should be reselected (by pressing the ◆ key), otherwise a new value for the limit may be selected. In both cases the display will return to that of the `Change limits` menu.

NOTES: No confirmation is required to change the value of a single limit.

Changing the value of limits will only affect the results of future tests and not those of any stored in memory.

3.3.2 SET NAME

This allows the user to view or change the name which will be printed out at the top of ART-875 results print-outs. This name is battery backed up (see Section 2.6) and is usually used to display a company or branch name.

An example display is as follows:

```
      SET NAME
TAYLOR COMMS. INC._
ABCDEFGHIJKLMNOPQRST
UVWXYZ. 0123456789<e
```


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The second line of the LCD shows the currently selected name which may contain up to 19 characters. The _ character is not part of the name and is used to show where the next character to be added to the name will go (this is useful when the last character added to the name is a space).

The bottom two lines of the LCD contain the characters which may be selected as part of the name i.e. upper case letters A to Z, dot, space, and digits 0 to 9. Selecting the < character will rub out the last character from the name and may be used to entirely remove an existing name. Selecting the e (for end) character will save the name as displayed and return the display to that of the Set up menu.

Initially the e character on the bottom line of the LCD will be flashing. This indicates that it is the currently selected character and that pressing the ◆ key at this point will end the Set name display. To select other characters, the ▲ and ▼ keys may be used to move the flashing character through the selectable characters before pressing the ◆ key.

3.3.3 SET PRINTER RATE

This allows adjustment of the printer communications speed and should be set to match that of your printer (see Section 8). This quantity is battery backed up (see Section 2.6).

3.4 ART BATTERY CHECK

This is selected from the main menu (see Figure 3) and indicates to the user if the ART-875 is operating from an AC supply or if operating from internal batteries, the amount of charge currently held by them.

Note that the amount of charge held by the batteries can not be determined if the ART-875 is operating from an AC supply.

Example displays:

```
ART BATTERY CHECK

power is AC supply
      ◆Quit
```

```
ART BATTERY CHECK

charge is medium
      ◆Quit
```

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When the ART-875 is operating from batteries, the display indications and approximate remaining ART-875 operating times are as follows:

CHARGE	APPROX. TIME
Low	15 minutes or less
Medium	15-50 minutes
High	50 minutes or more

Whilst ART battery check is selected the display will be automatically updated if any changes occur.

Pressing the ◆ key returns the display to that of the main menu.

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4 IMPORTANT INFORMATION FOR ALL TESTS

4.1 CONNECTING TO A CELLULAR TELEPHONE

Unless otherwise stated, for all tests the RF socket of the ART-875 should be connected to the RF socket of cellular telephone to be tested using the BNC to BNC coaxial cable supplied.

The method of achieving the connection to the cellular telephone's RF socket is dependent on the type of the cellular telephone, and the type of installation. In all cases the cellular telephone's usual aerial should be disabled or disconnected. (If in doubt, the cellular telephone's user and/or service manuals should be consulted).

Unless testing of the cabling of an installation is specifically required, the RF connection should be made as near to the main body of the cellular telephone as possible, as any cabling between the cellular telephone and the ART-875 over and above the supplied 1 metre cable, will cause inaccuracies in power measurements made by the ART-875.

In most cases, the RF socket of the cellular telephone will not be of the correct type to connect with the supplied cable, in these cases an adaptor must be used. For this purpose, the optional RF connector adaptor kit contains adaptors for several commonly used connectors.

4.2 STARTING A TEST

When a test is selected from either the `Automatic test` or `Manual tests` menus, the user may be prompted to select an operational mode for the test. Once this has been done, the ART-875 will start to transmit a signal to the cellular telephone.

If this point has been reached within 10 seconds of switching on, the ART-875's time base will not have had time to warm up and the message `OCXO warmup delay` will be displayed on the LCD until the required time has elapsed.

4.3 GETTING THE CELLULAR TELEPHONE IN SERVICE

All cellular telephones have a preferred cellular system which can be set to either A (Non-wireline) or B (Wireline). The ART-875 can simulate either system and must be set to simulate the preferred system of the cellular telephone to be tested.

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At the start of each test, the ART-875 will display on the LCD, the name of the cellular system currently being simulated, and one of the following messages.

`wait for service` *(1)*

or `power up mobile` *(2)*

In case *(1)* the cellular telephone should be powered up if it is not already so.

In case *(2)* the cellular telephone should be powered down if already powered up, then powered up.

In both cases, after a few seconds, the cellular telephone should go into service i.e. it should recognise and lock on to the signal sent from the ART-875 and indicate this by either extinguishing a 'No Svc' or 'No Service' indicator, or by lighting up a 'Svc' or 'Service' indicator (if in doubt, consult the telephone's user handbook).

If after about 10 seconds the cellular telephone has not gone into service, either the ▲ key or the ▼ key should be used to select the alternative cellular system. If the cellular telephone still fails to go into service there may be a fault in the cabling between the cellular telephone and the ART-875, if not, the fault is probably with the cellular telephone's RF receiver or decoding circuitry.

4.4 CONTINUING THE TEST

For all tests except `Receiver test`, once the cellular telephone has gone into service, the test continues

in case *(1)* above;

> by the user placing a call on the cellular telephone. With most cellular telephones this may be achieved by simply pressing the SEND key on its handset, with others, one or more digits may have to pressed first (if in doubt, consult the phone's user handbook). The ART-875 will display the message `Call received` and the test will proceed.

in case *(2)* above;

> automatically by the cellular telephone registering after a few seconds. The ART-875 will display the message `Mobile registered` and the test will proceed.

If the above does not happen, then the test should be retried with the alternative cellular system. If there is still no response then there may be a fault with the cellular telephone's logic or RF transmitter circuitry.

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4.5 WHEN THERE ARE TWO SPEAKERS OR MICROPHONES

A cellular telephone may have more than one microphone and loudspeaker. Often there is one microphone and loudspeaker in the handset and an optional external microphone and loudspeaker for 'hands free' operation. The cellular telephone may have the facility to switch between which ones are enabled, so when a cellular telephone's microphone or loudspeaker is involved in an ART-875 test, the one that should be used is the one that is currently enabled by the cellular telephone (if in doubt, consult the telephone's user handbook).

4.6 AMBIENT NOISE

Apart from when an audio or microphone test is being performed, noise which could be picked up by the cellular telephone's microphone during a test should be kept to a minimum as the presence of a large audio signal may affect some of the measurements made by the ART-875.

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5 AUTOMATIC TEST

5.1 GENERAL

The ART-875 automatic test is a comprehensive sequence of tests designed to test as many of the cellular telephone's operational parameters as possible with the minimum of user effort. To fully test the telephone however, a Sinad Test (see Section 6.2), and for cellular telephones installed in a vehicle, a VSWR check (see Section 6.9), should also be carried out.

The Automatic test menu is selected from the main menu (see Figure 3) from where a test may be performed by selecting Full test or Quick test. The Quick test achieves most of the testing done by Full test but by omitting some of the less important measurements (e.g. testing only low, medium and high power levels rather than all eight) completes the test in a shorter time.

The results of automatic tests (Full or Quick) may be displayed on the LCD or sent to a printer using Results log and Print entire log.

5.2 OPTIONS

Options may be used to configure the automatic test to a small extent and to accommodate peculiarities in the behaviour of some cellular telephones. Apart from the 2nd microphone option, unless there is a known or suspected problem with a cellular telephone, the options should not be changed from their factory settings.

Options are battery backed up and may be accessed via the Options menu (see Figure 3).

Any alterations to the options made by the user may be effectively cleared by selecting Set factory options which resets all options to their factory settings. This selection must be confirmed and a further selection of Yes or No is required (see Figure 3).

An option may be set to one of two values, either Included or Not included. The current value of a option may be viewed or changed by selecting the Change options menu and from there selecting the individual option to be viewed or changed.

When an individual option has been selected from the Change options menu, the ART-875 will display a menu of the two values which may be selected in which the ◆ symbol will be initially displayed alongside the value which is currently selected. If no change is required, the current value should be reselected (by pressing the ◆ key), otherwise a new value for the option may be selected. In both cases the display will return to that of the 'Change options' menu.

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NOTES: No confirmation is required to change the value of a single option.

Changing the value of options will only affect future tests and not the results of any stored in memory.

There are four options for the automatic test which may be used as follows:

`Register (global)`

Setting this option to `Not included` causes the registration test to be omitted and may allow a cellular telephone to be partially tested which would otherwise fail to start the automatic test. This option does not apply to the Quick test which always omits registration (it does however apply to the Manual tests (section 6), allowing those tests which are normally started with a registration to be started with an initiation).

`Error corr. test`

Setting this option to `Not included` causes the error correction test to be omitted and may allow a cellular telephone to pass the automatic test which would otherwise fail at `Error correct` . Note that this option applies to the Full test only, the Quick test always omits the error correction test.

`Stop before page`

Setting this option to 'Included' may allow a cellular telephone to pass the automatic test which would otherwise fail at `Call to mobile`.

`2nd microphone`

Setting this option to 'Included' allows testing of both microphones in an installation which includes a hands free microphone (see Section 4.5).

5.3 PERFORMING THE TEST

After selecting `Full test` or `Quick test`, the ART-875 will start to perform the test and inform the user of the test's progress and give instructions at various points using the LCD and the audio output of the cellular telephone.

At the end of the test the conclusion will be displayed on the LCD unless the test has been stopped by the user before a conclusion could be made.

If, when performing a Full test, the cellular telephone to be tested goes into service but has a fault whereby it can not perform a registration, none of the remainder the automatic test can normally be carried out. If the cellular telephone is however capable of placing a call, setting the `Registration` option to be not included (see Options above) may allow partial testing.

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The instructions given by the ART-875 during the test and user action are as follows.

(i) `Power up mobile...`

This instruction arises from an optional part of the Full test (see Section 5.2). If given, user action is as described in Section 4.

(ii) `Wait for service then send a number..`

Action for this instruction is as described in Section 4 but note that if the above instruction has already been given, the cellular system will have already been selected and no opportunity will be given to change it here.

(iii) `Power mobile off,on, wait for service...`

This instruction arises from an optional part of the test (see Options above). If given, user action is to switch off the cellular telephone, switch it back on again, and then wait for the phone to go into service (see Section 4). The test then continues by pressing either the ▲ or ▼ key.

(iv) `Answer call...`

At this point, the cellular telephone should be ringing. This should be noted for subsequent entry on the results print-out if one is required. Note that the cellular telephone may have audio, visual or both ringing indicators and that facilities may exist for them to be enabled, disabled or in the case of an audio ringing indicator, to have its volume adjusted (if in doubt, consult the cellular telephone's user handbook).

Action here may be different for different cellular telephones but typically is to either lift the handset from its cradle, or to press the SEND key (again, if in doubt, consult the telephone's user handbook).

This instruction will be displayed by the ART-875 for a maximum of one minute. If during that time the ART-875 has not detected that the call has been answered, the test will be deemed to have failed.

(v) `Test microphone 1...` or
`Test microphone 2...`

The microphone to be tested (see Section 4.5) should be tested by providing it with a high amplitude audio input. This may be achieved by simply blowing hard into the microphone. When the ART-875 detects a deviation caused by the audio input greater than a preset minimum, it will wait for a further one second to detect a maximum and then move on to the next part of the test.

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This instruction will be displayed by the ART-875 for a maximum of one minute. If during that time the ART-875 has not detected the required minimum deviation, this part of the test will be deemed to have failed and the test will continue.

(vi) `Check audio then send 123456789*0#...` or
`Check audio then send flash...`

At this point a series of rising and falling tones will be heard in the cellular telephone's loud-speaker(s) (see Section 4.5). The quality of these tones should be noted for subsequent entry on the results print-out if one is required.

The idea of this part of the test is to test the keys on the cellular telephone's handset by performing a 'flash request'. Action here may be different for different cellular telephones but typically is to press all 12 digit keys in the specified order if specified in the instruction given by the ART-875, and then to press the SEND key (if in doubt, consult the cellular telephone's user handbook).

This instruction will be displayed by the ART-875 for a maximum of one minute. If during that time the ART-875 has not detected the flash request, this part of the test will be deemed to have failed and the test will continue.

(vii) `Terminate call...`

At this point a single intermittent tone will be heard in the cellular telephone's loudspeaker (see Section 4.5).

Action here may be different for different cellular telephones but typically is to replace the handset in its cradle or to press the END key (if in doubt, consult the cellular telephone's user handbook).

This instruction will be displayed by the ART-875 for a maximum of one minute. If during that time the ART-875 has not detected the call being ended the test will be deemed to have failed.

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5.4 THE TEST RESULTS LOG

The ART-875 has the ability to store in a log the results of the 10 most recently performed automatic tests. The results are battery backed up (section 2·6) and so may be printed or displayed away from the place of test.

From the Automatic test menu, the entire log may be printed by selecting `Print entire log`, or operations on individual results made by selecting `Results log`. If at this point, there are no sets of results stored in the log, a message to that effect will be displayed on the LCD.

Selecting `Results log` when the log is not empty will bring up a menu of the stored results (see Figure 3). For each set of stored results, there will be a line in this menu displaying the associated MIN or ESN. When this menu is first selected, the ◆ symbol will be positioned alongside the line corresponding to the newest set of test results, the last MIN or ESN on the menu corresponding to the oldest set of results. Selecting `Change index type` (the second last line of this menu) will switch between displaying MINs or ESNs.

Selecting a set of results from the log will bring up a menu of operations which may be performed on those results i.e. send the results to a printer, display the results on the LCD or remove the results from the log. The `Choose another` option allows the user to go straight back to the menu of logged results, selecting `Quit` will return the display to that of the Automatic test menu.

5.5 THE TEST RESULTS PRINT-OUT

A sample print-out from the ART-875 automatic Full test is shown in Figure 4. For the Quick test, the format of this printout is the same, but some of the measurements will be omitted.

The three items on the left near the top of the print-out: `MIN`, `SCM` and `ESN` contain identification and type information obtained from the cellular telephone. On the right near the top of the print-out is displayed the name described in Section 3.3.2 and the type of cellular system which the ART-875 was set to simulate at the time the automatic test was carried out.

The bulk of the print-out contains the measured values and results obtained during the automatic test. The following points are specific to the results as they appear on the print-out.

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SMITH MYERS ADVANCED RADIO TESTER 875 00/00 AUTOMATIC TEST RESULTS

MIN:321 456-7890
SCM:1,C,832
ESN:255/00/123456 = FF01E240

YOUR COMPANY NAME

Tested on system B (Wireline)

PARAMETER		NOMINAL & ERROR LIMIT		VALUE	ERROR	RESULT
Tx power MAC	0	3.00W	+/-60%=+2/-4dB	5.15W	+71.6%	*FAIL*
	1	1.19W	"	1.27W	+6.7%	pass
	2	475mW	"	499mW	+4.9%	pass
	3	189mW	"	194mW	+2.2%	pass
	4	75.4mW	"	74.5mW	-1.1%	pass
	5	30.0mW	"	30.3mW	+1.1%	pass
	6	11.9mW	"	12.4mW	+4.5%	pass
	7	4.8mW	"	5.2mW	+8.9%	pass
Tx freq chan	991	824.04MHz	+/-1.5kHz	824.03992MHz	-80Hz	pass
	384	836.52MHz	"	836.51988MHz	-120Hz	pass
	799	848.97MHz	"	848.96984MHz	-160Hz	pass
SAT frequency	0	5970.0Hz	+/-1Hz	5970.0Hz	+0.0Hz	pass
	1	6000.0Hz	"	6000.0Hz	+0.0Hz	pass
	2	6030.0Hz	"	6030.0Hz	+0.0Hz	pass
ST frequency		10000.0Hz	+/-1Hz	9999.8Hz	-0.2Hz	pass
SAT deviation	0	2.00kHz	+/-25%	2.01kHz	+0.5%	pass
	1	2.00kHz	"	1.94kHz	-3.0%	pass
	2	2.00kHz	"	1.98kHz	-1.0%	pass
ST deviation		8.00kHz	+/-15%	7.84kHz	-2.0%	pass
Peak deviation	1	12.3kHz max	9kHz min	11.41kHz	+0.0%	pass
	2	12.3kHz max	"	12.56kHz	+2.1%	*FAIL*
ST len handoff		50ms	+/-10%+/-10ms	50ms	+0.0%	pass
flash		400ms	"	402ms	+0.5%	pass
release		1.8s	"	1.798s	-0.1%	pass

Call processing

Registration	pass
Call by mobile	pass
Handoffs	pass
Error correct.	pass
Clear by system	pass
Call to mobile	pass
Mobile alert	pass
Call answered	pass
Number sent	pass
Clear by mobile	pass
Ringing heard?	_____
Audio tones OK?	_____

COMMENTS: _____

CONCLUSION: FAILED

TESTED BY: _____ DATE: _____

Figure 4 – Sample Printout

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- In the PARAMETER column, the name displayed may be abbreviated if similar to the one above.

- In the NOMINAL & ERROR LIMIT column, where an error limit applies to several values it will be displayed only once, with subsequent occurrences replaced by dittos.

At the right side near the bottom of the printout is space for the user to fill in the results of two quantities not determined by the ART-875, followed by the test conclusion. If the results filled in by the user are not passes, the test conclusion should be modified accordingly.

At the left side near the bottom of the printout is space for the user to fill in any suitable comments, his/her name and the date that the test was carried out.

5.6 THE TEST RESULTS DISPLAY

The test results display allows the user to view on the LCD, most of the information which appears on the test results print-out. It takes the form of a menu of the identification and type information obtained from the cellular telephone and all names in the PARAMETER column of the print-out with their corresponding results (see Figure 3).

Selecting an item from the menu will produce a display with more information (if there is any) about that item.

This display will contain in its first line the description of the selected item as it appeared on the menu. On the second line will be displayed the second form of the ESN, if ESN has been selected, the NOMINAL & ERROR LIMIT information if a measured value has been selected, or nothing otherwise. On the third line will be displayed the VALUE and ERROR information if a measured value has been selected and a value was obtained, an RF POWER LOW message if this occurred whilst trying to obtain this result, or nothing otherwise.

The Test results menu may be returned to by pressing the ◆ key, or the Automatic test menu may be returned to by pressing either the ▲ or ▼ key (this last feature, which violates normal menu structure, is included because as the test results menu is so long, selecting Quit in the conventional manner could be somewhat laborious).

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5.7 INTERPRETING THE TEST RESULTS

The conclusion of the automatic test may be one of the following:

- PASSED
  This indicates that the cellular telephone has passed the automatic test with the currently selected limits and options.

- FAILED
  This indicates that one or more parts of the test has failed. The test results should be examined to determine the cause(s) of the failure.

- RF POWER LOW
  This indicates that the received RF signal from the cellular telephone was too low to allow accurate measurements to be made and the test was abandoned.

The identification and type information obtained from the cellular telephone should be interpreted as follows.

- MIN = Mobile Identification Number.
  This is the cellular telephone's ten digit directory telephone number.

- SCM = Station Class Mark.
  The first field is a single digit denoting power class:

  1 - High power
  2 - Medium power
  3 - Low power

  The second field is a single letter denoting the transmission capability:

  C - Capable of continuous transmission only
  D - Capable of discontinuous as well as continuous transmission

  The third field is a number denoting channel or bandwidth capacity:

  666 - channels 1 to 666
  832 - channels 1 to 799, and 991 to 1023

- ESN = Equipment Serial Number.
  This is factory set and contains manufacturer, equipment and hardware identity numbers. It is displayed in two commonly used forms: the first is split into fields and displayed in decimal, the second is displayed as a single 8-digit hexadecimal number.

The main test result fields should be interpreted as follows:

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- PARAMETER - the name of the measured quantity or process tested. If the number received when testing the cellular telephone's handset keypad was not correct, the received number will be displayed instead of the words Number sent.

- NOMINAL & ERROR LIMIT - the values used to determine if a measured value passes or fails. In all cases except Peak deviation these will be the nominal value for the measured quantity followed by the current allowable error. In the case of Peak deviation the maximum and minimum allowable values are displayed.

- VALUE - the actual value for this quantity measured by the ART-875.

- ERROR - the difference between the nominal (or in the case of Peak deviation the nearest allowable) and the actual values. For frequency measurements the error is displayed as an absolute value, otherwise it is displayed as a percentage of the nominal (or the nearest allowable) value.

- RESULT - the result of this part of the test. This may be one of the following:

  PASS or P
  The measured value is in range, or the call processing test has passed.

  FAIL or *F
  The measured value is out of range, or the call processing test has failed.

  (blank)
  This part of the test was not attempted because of an earlier failure or because the test has been stopped by the user.

  ---- or --
  This part of the test was not attempted because it has been set to Not included in the Options menu (See Section 5.2) or because a Quick test was being performed.

Channel numbers used for carrier frequency measurement correspond to low, medium and high frequencies across the range of the cellular telephone being tested.

If Call to mobile fails, this may be because the cellular telephone is in the vicinity of an interfering base station, or because it can not clear down a call automatically without operator intervention. If this is the case, setting the Stop before page option to be included (see Section 5.2) may cure the problem.

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6 MANUAL TESTS

The following tests may all be selected from the `Manual tests` menu (see Figure 3).

6.1 GET MOBILE INFO

This test provides a quick and easy way to obtain the MIN, SCM and ESN (see Section 5.6) from the cellular telephone. The test is started as described in Section 4 and the information displayed on the LCD.

For example:

```
INFO  ▲▼PRINT  ◆QUIT
MIN:321 456-7890
SCM:1,C,832
ESN:255/00/123456
```

If a printer is attached to the ART-875 at this point, the received information may be printed out by pressing either the ▲ or ▼ keys.

NOTES: The ESN is displayed in one form only.

This test will be done using a registration or an initiation depending on the value of the Automatic test option `Register (global)` (see Section 5.2).

6.2 SINAD TEST

This test provides a method of checking the overall performance of the cellular telephone's receiver circuitry.

For each type of cellular telephone to be tested, a method is needed to tap into the speaker output. This may involve dismantling the handset or obtaining a connector for a hands-free loudspeaker socket if one exists (see Section 4.5). For details of how this may be achieved, the cellular telephone's service manual should be consulted.

The red and black clips of SINAD cable supplied with the ART-875 should be connected to the positive and negative sides of the cellular telephone's speaker output respectively. The 5 pin connector of the SINAD cable should be connected to the socket labelled 'PRINTER' on the ART-875 back panel (see Figure 2). If a printer cable already occupies this socket, it will have to be temporarily disconnected.

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With the SINAD cable connected up, the test should be started by setting up a call as described in Section 4.

If the speaker output level is unsuitable for obtaining a SINAD measurement, the ART-875 will instruct the user to adjust the volume until a suitable level is obtained. The speaker output volume control of a cellular telephone is usually located on its handset.

Once the correct output level has been obtained, the ART-875 will instruct the user to `Insert test pads...` and start to display the SINAD measurement at the ART-875's normal RF output level. At this point, the two supplied 20 dB pads should be inserted between the cellular telephone's RF socket (plus any necessary adaptor) and the supplied RF cable. The length of any cable between the pads and the cellular telephone should be kept to a minimum. When the pads are being inserted, the RF path must not be broken for more than a few seconds or the cellular telephone will terminate the call.

The SINAD measurement now displayed will be being made at the reduced RF output level of –113 dB and should be 12 dB or more.

The test is ended by pressing the ◆ key.

IMPORTANT: The pads should not be left in position after the test since they will interfere with the operation of other tests and may be damaged by high power output from the cellular telephone.

6.3 RECEIVER TEST

This test provides a quick and easy method of measuring the sensitivity of the cellular telephone's receiver.

Despite what is displayed on the LCD at the start of this test, no test pads should be inserted initially. The cellular telephone should first be 'got into service' as described in Section 4 to ensure that the equipment is all correctly set up. The two supplied 20 dB pads should then be inserted between the cellular telephone's RF socket (plus any necessary adaptor) and the supplied RF cable. To prevent possible interference from a local base station, the length of any cable between the pads and the cellular telephone should be kept to a minimum.

If its receiver is working correctly, the cellular telephone should go back into service with the resulting low level signal from the ART-875. Otherwise one of the 20 dB pads should be removed and the following table used to determine the approximate sensitivity of the receiver.

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Maximum Attenuation with Cellular Telephone in Service	Approximate Receiver Sensitivity
none	Between -73 and -93 dB
20 dB	Between -93 and -113 dB
20 + 20 dB	Better than –113 dB

The test is ended by pressing the ◆ key.

IMPORTANT: The pads should not be left in position after the test since they will interfere with the operation of other tests and may be damaged by high power output from the cellular telephone.

6.4 MICROPHONE TEST

This test is typically used to test one of the cellular telephone's microphones (see Section 4.5) or to adjust peak voice deviation if this was found to be necessary in the automatic test.

To aid adjustment of the cellular telephone, this test displays deviation using a peak hold facility. This means that a measured value of deviation will be displayed on the LCD only if it is greater than the value already displayed. The peak held may be reset either manually (by the user pressing either the ▲ or ▼ keys) or automatically (by the ART-875 approx. every 2 seconds).

The first thing which must be done on selecting this test is therefore to select which reset method will be used. This is done using the SET RESET MODE menu (see Figure 3).

Once the reset method has been selected, the test is started as described in Section 4. The microphone should be tested as described in Section 5.3(v).

The second line of the LCD will display an analogue representation of the current deviation caused by audio from the microphone, the more black blocks displayed, the higher the deviation. The analogue display does not use the peak hold facility.

The third line of the LCD will display the deviation digitally and a pass/fail result based on the appropriate limit in the Set up menu (see Section 3.3.1). Both of these quantities use the peak hold facility described above.

The test is ended by pressing the ◆ key.

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6.5 SAT ANALYSIS

This test displays the frequency or deviation of the SAT transponded by the cellular telephone, and may be used as an aid to adjusting them. The test opens with a menu from which the user must select either `Deviation` or `Frequency` (see Figure 3).

Once the test has been started as described in Section 4, the SAT number (0, 1, or 2) will be displayed on the first line of the LCD. This may be changed by use of the ▲ and ▼ keys.

On the second line of the LCD will be displayed the measured value, the error from the nominal value and a pass/fail result based on the appropriate limit in the `Set up` menu.

The test is ended by pressing the ◆ key.

6.6 ST ANALYSIS

This test displays the frequency and deviation of the ST sent by the cellular telephone, and may be used as an aid to adjusting them. The test opens with a menu from which the user must select either `Non-ringing` or `Ringing` (see Figure 3).

The test is started as described in Section 4 using either a registration or an initiaition depending on the value of the Automatic test option `Register (global)` (see Section 5.2)..

The measured ST frequency and deviation will be displayed on the second and third lines of the LCD respectively. Also displayed are the errors from the nominal values and pass/fail results based of the appropriate limits in the `Set up` menu.

If `Ringing` was selected, the cellular telephone should ring until either the test is ended by the user or the 'call' is answered.

The test is ended by pressing the ◆ key.

6.7 POWER/CONTINUITY

This test may be used to measure or adjust a cellular telephone's output power, to check cable continuity or VSWR (Section 6.9), and where applicable, to check its ability to operate in discontinuous transmission (DTX) mode.

The test opens with a menu from which the user should select the transmission mode for the cellular telephone to use.

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6.7.1 POWER MEASUREMENT

The transmission mode selected should be Continuous and the test started as described in Section 4. On the third line of the LCD will be displayed the current Mobile Attenuation Code (MAC) which may be changed by using the ▲ key and the channel number which may be changed using the ▼ key.

On the second line of the LCD will be displayed the measured power, the percentage error from the nominal value and a pass/fail result based of the appropriate limit in the Set up menu (see Section 3.3.1). If the measured value is out of range, an audio as well as a visual indication will be given. This is of most use when performing a cable continuity check (see below).

The test is ended by pressing the ◆ key.

6.7.2 CABLE CONTINUITY CHECK

This test should be made if it is suspected that there may be an intermittent connection in the cabling between the cellular telephone and its aerial. The test is performed as above in 6.7.1, but note that there is no need to make any adjustments with the ▲ or ▼ keys (automatic attenuation adjustment may however, still occur in the case of a cellular telephone of power Class 1). The cable or connection suspected of causing a problem should be tested by agitating it manually. If a continuity break occurs, there will be a marked drop in the power level detected by the ART-875. This will be indicated both on the ART-875's LCD and loud speaker. The audio indication is particularly useful when the cable or connection being tested is not close to the ART-875.

6.7.3 CHECKING DTX

For this test Zero power DTX or Low power DTX should be selected and the test started as described in Section 4. At this point the ART-875 will check the cellular telephone's SCM for DTX capability. If it is not found, the ART-875 will display an appropriate message on the LCD and exit the test. Otherwise the test will continue as in 6.7.1 but without any audio indication for power being out of range. If the DTX mode is working correctly, the received power should go up and down as the user speaks and stops speaking into the cellular telephone's microphone (see Section 4.5). For Low power DTX the power level should drop no more than 8dB (e.g. for a class 1 cellular telephone at MAC 0, the nominal power is 3W, the Low power DTX power may drop to 475mW) otherwise the power may drop to zero. Note however that some manufacturers implement both DTX modes as Low power DTX.

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6.8 CARRIER FREQ. TEST

This test displays the error in the cellular telephone's carrier frequency and may be used as an aid to adjusting it.

Once the test has been started as described in Section 4, the current channel number will be displayed on the third line of the LCD. The channel number may be changed with the use of the ▲ and ▼ keys. There are three channel numbers available corresponding to low, medium and high frequencies across the range of the cellular telephone being tested.

On the second line of the LCD will be displayed the frequency error for the current channel and a pass/fail result according to the appropriate limit set in the `Set up` menu (see Figure 3).

The test is ended by pressing the ◆ key.

6.9 CHECKING VSWR

Measuring VSWR with the ART-875 requires the following additional equipment:

- a bi-directional through line power meter
- a variable air dielectric coupler
- two coaxial RF cables
- various RF connector adaptors

The equipment should initially be set up as shown in Figure 5 but with cable 'B' disconnected at the RF coupler.

WARNING: TO PREVENT THE POSSIBILITY OF INJURY WITH THE EQUIPMENT SET UP AS DESCRIBED, THE EXPOSED CONNECTOR OF THE RF COUPLER MUST NOT BE TOUCHED.

The ART-875 'POWER/CONTINUITY' test should then be used in continuous transmission mode to set the cellular telephone to transmit at MAC 0, and then cable 'B' connected as shown.

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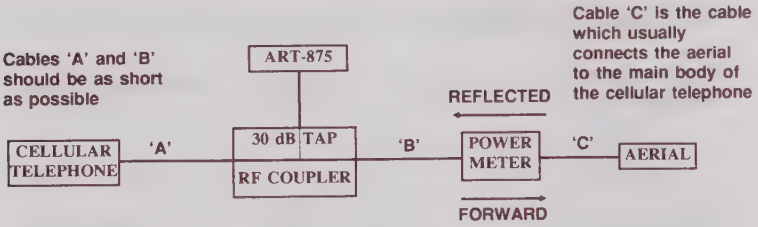

Figure 5 – VSWR Set Up

Values for forward power (F) and reflected power (R) should be obtained from the external power meter and the VSWR value equated to the following expression:

$$\frac{1 + \sqrt{R / F}}{1 - \sqrt{R / F}}$$

Ideally, there will be no power reflected and the VSWR value will be 1. In practice however, an acceptable VSWR value for a good installation should be between 1 and 1·5.

For example, for an installation of a cellular telephone with 3 watts forward power, the reflected power should be less than 100 mW (0·1 watt).

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7 CHANNEL NUMBERS

The ART-875 starts each test on control channel number 313 for System A (Non-wireline) or 354 for System B (Wireline).

The voice channels used for hand-off tests are 1, 333, 666 for a 666 channel cellular telephone and 991, 384, 799 for an 832 channel cellular telephone.

All other voice channel tests are made on channel 333 for a 666 channel cellular telephone or channel 384 for an 832 channel cellular telephone.

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8 SINAD/PRINTER CONNECTIONS

The pin-out of the 5 pin printer/SINAD socket as viewed from the outside of ART-875 is as follows:

The supplied SINAD cable comprises a male 180° 5 pin DIN connector, one metre of cable and two sprung clips which are connected as follows:

DIN	SIGNAL	CLIP
1	Speaker +	Red
3	Speaker –	Black

The optional printer cable comprises a male 180° 5 pin DIN connector, one metre of cable and a male 25 pin D-type connector which are connected as follows:

DIN	SIGNAL	D-TYPE
2	Ground	7
4	ART-875 transmit data	3
5	Printer transmit data	2

The optional PC cable is the same as the printer cable except for the D connector which is female instead of male.

If a printer is to be connected directly to the ART-875, it should be ASCII compatible, have at least 80 columns, and an RS232C serial interface set as follows.

- 1200, 9600 or 19200 baud (see Section 3.3.3)
- 8 bits per character
- no parity
- 1 stop bit
- XON/XOFF hand-shaking

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9 SPECIFICATIONS

PHYSICAL

Power supply (240 V version) 220-240 V, 50 Hz AC
Power supply (120 V version) 110-120 V, 60 Hz AC
Fuse 250 mA quick-blow
Internal batteries sealed lead acid
Power connector male IEC
RF connector female BNC
Printer/SINAD connector female 180° 5 pin DIN
Operating temperature 0 to 40°C
Storage temperature –20 to +60°C
Dimensions (approx) 75 x 275 x 250 mm
Weight (approx) 3·6 kg

TIME BASE

Operating temp. stability < ± 0·2ppm
Aging per annum < ± 1ppm
Warm up < 20 seconds

RF OUTPUT

Frequency range 869 to 894 MHz
Signal level –72 ± 2 dBm
Data frequency 10,000 ± 1 bits/second FSK
Data deviation ± 8 kHz ± 10%
SAT frequency 5·97,6·00, 6·03 kHz ± 1 Hz
SAT deviation ± 2 kHz ± 10%

RF INPUT

Frequency range 824 to 849 MHz
Signal level –22 to +10 dBW

MEASUREMENT ACCURACIES

Carrier frequencies as time base, resolution 40 Hz
Power (MAC 0-7) ± 15%
Audio frequencies ± 1 Hz
Deviations ± 8% ± 0·1 kHz
ST lengths ± 10 mS
SINAD ± 1 dB at –113 dBm, 8 to
. . . . . 20 dB displayable

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10 ADDITIONAL INFORMATION

10.1 AN INTRODUCTION TO AMPS

For the purposes of cellular communications, a country is split up into a number of areas called cells. Each cell is under the supervision of a *base station* (or *land station*) which relays to the telephone network all calls to and from any cellular telephones in the cell.

Because of the low power levels used in cellular radio, radio emissions in one cell will not reach other cells some distance away. This means that a particular communications channel may be used simultaneously in several different cells provided that the cells are not too close to each other. It is for this reason that the cellular system makes much more efficient use of the airwaves than any previous radio communication system.

Each communications channel is full duplex i.e. it comprises two frequencies, one for base station transmissions, one for cellular telephone transmissions.

Each base station transmits a continuous stream of information on a *control channel*. When a cellular telephone is switched on, it will scan the control channels and lock onto (go into service on) the strongest recognizable control channel signal. If a cellular telephone moves from one cell to another, the control channel signal from the first cell will start to fade and the cellular telephone will rescan and lock onto the control channel signal in the second cell.

When a cellular telephone is first switched on and at regular intervals afterwards, it may perform a *registration*, that is, it will transmit a message to the base station to which it is currently locked, indicating that it is available to receive calls in that area. Thus, as a cellular telephone moves around the country, the cellular network knows if it is switched on, and if it is, approximately where it is.

If a call is to be made to the cellular telephone, each base station in its area will send out a *page* message on the control channel. The cellular telephone detects this message in the control channel information stream and transmits a response. The base station will then assign a *voice channel* for the ensuing conversation, and send an *alert* command which causes the cellular telephone to start ringing. When the cellular telephone user answers the call, the audio path is opened and the conversation may proceed.

Placing a call from the cellular telephone is achieved by sending an *origination* message on the control channel to the base station. The base station will then assign a voice channel and conversation may proceed.

If, during a call, the cellular telephone moves out of the one cell and into a new one, the base station in the first cell will *handoff* (transfer control of) the call to the base station in the new cell. This is achieved by transmitting on the current voice channel, a message instructing the cellular telephone to start

using a new voice channel (one controlled by the second base station). The cellular telephone will confirm the transfer by responding to the base station with an *ST*.

During a conversation, to set up a conference call or for other reasons, the cellular telephone can be made to send a *flash request*. This involves the cellular telephone sending an ST message and possibly a dialled number.

A call may be terminated by the base station or the cellular telephone. In both cases the cellular telephone sends a *release* message to the base station in the form of an ST.

10.2 CELLULAR TRAINING COURSES

Further information on AMPS and cellular systems may be obtained at cellular training courses. These are available from a number vendors including cellular test equipment manufacturers, cellular telephone manufacturers, air time providers and independent training companies.

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11 GLOSSARY

alert	A message sent to a cellular telephone to instruct it to turn on its ringing indicator.
AMPS	Abbreviation for 'Advanced Mobile Phone Service'. This is the cellular radio system used in the USA operating in the 900 MHz band.
base station	The source and destination of all transmissions to and from a cellular telephone.
BNC	A type of cable connector frequently used for RF applications.
control channel	A channel containing only digital messages to and from a cellular telephone used to set up calls.
dB	Abbreviation for decibel.
dBm,dBW	See decibel.
decibel	One bel represents a 10 to 1 ratio of power at two points. The decibel or dB represents one tenth of a Bel and is defined as follows: Power ratio in decibels = $10\times \log_{10}$(power at point 1/power at point 2) An absolute power level may defined as a number of decibels above or below a second absolute power level. Often used as this reference are a watt or a milliwatt. Thus one has the expressions e.g. 20dBm = 20 decibels above a milliwatt = 100 milliwatts or –2dBW = 2 decibels below a watt ≈ 0·45 watts.
deviation	A measure of the magnitude of signal modulated on a carrier.
Discontinuous Transmission or VOX	This capability is given to some cellular telephones (usually battery powered ones) as a power saving feature. In this mode, during a conversation a cellular telephone will turn on its transmitter only when there is audio to be transmitted. If a cellular telephone is capable of discontinuous transmission, this should be reflected in its SCM.
DTX	Abbreviation for Discontinuous Transmission.
flash request	A type of ST message.

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handoff	The transferring of a call from one channel to another.
land station	Synonym for base station.
LCD	Abbreviation for 'Liquid Crystal Display'.
MAC	Abbreviation for 'Mobile Attenuation Code'. A value in the range 0-7 which controls the level of a cellular telephone's output power.
mobile	Synonym for 'cellular telephone'.
origination	Placing of a call from a cellular telephone.
page	Means the same as 'Call to mobile'.
register, registration	A message sent by a cellular telephone to a AMPS base station (and the ART-875) to indicate that it is active.
release	Termination of a call.
RF	Abbreviation for 'Radio Frequency'. For the purposes of this manual, this means frequencies in the range 824-894 MHz.
SAT	Abbreviation for 'Supervisory Audio Tone'. SATs are transmitted by AMPS base stations (and the ART-875) and are transponded by the cellular telephone. A SAT may be one of three frequencies: 5·97, 6·00 , or 6·03 kHz.
SCM	Abbreviation for 'Station Class Mark'. Fully described in Section 5.6.
SINAD	Abbreviation for 'SIgnal Noise And Distortion'. SINAD is a measure of a cellular telephone's capability to perform at low signal levels.
ST	Abbreviation for 'Signalling Tone'. STs are varying lengths of a tone of 10 kHz transmitted to AMPS base stations (and the ART-875) by a cellular telephone.
voice channel	A channel used to carry a conversation.
VSWR	Abbreviation for 'Voltage Standing Wave Ratio'. This is a measure of the efficiency of power transmission from the cellular telephone through the aerial, and is an important factor in the overall performance of an installation. It is of most pertinence to a cellular telephone installed in a vehicle. A poor VSWR may result from a badly positioned aerial or from an aerial which is not well matched with the cellular telephone.

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